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(71) Applicant
Eric Smith,
"Oakhill",
Stafford Road,
Uttoxeter,
Staffordshire.
(72) Inventor
Eric Smith
(74) Agent and/or Address for Service
George Fuery & Co.,
Whitehall Chambers,
23 Colmore Row,
Birmingham B3 2BL.

(54) Heat exchanger

(57) A heat exchanger is made, particularly from aluminium sheet or foil laminated with brazing metal, as a stack of like parallel fin plates 16 formed with projections 10, each plate being reversed 180° with respect to the next, and the projections together forming a tube extending at right angles to the sheets.

The fin plates form a sinuous tube passage by an eccentricity of the apertures 12 through the projections 10, and with the stack further strengthened by tags 14 from each plate contacted with the next adjacent one.

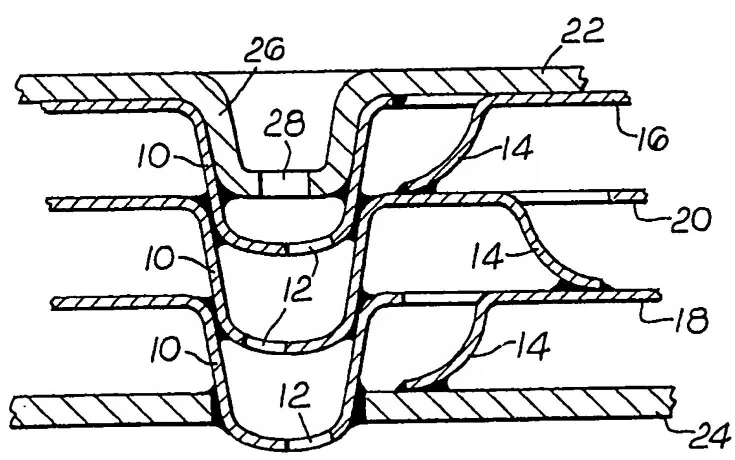


Fig. 3

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

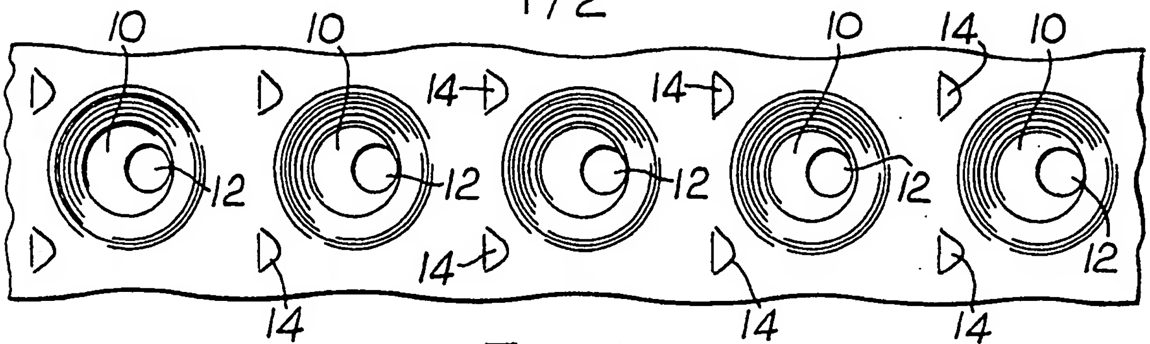


Fig. 1

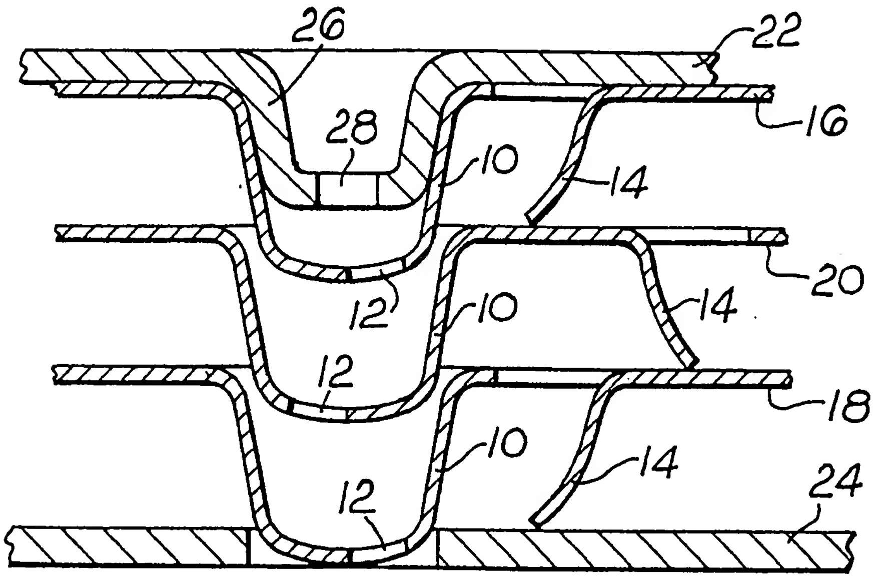


Fig. 2

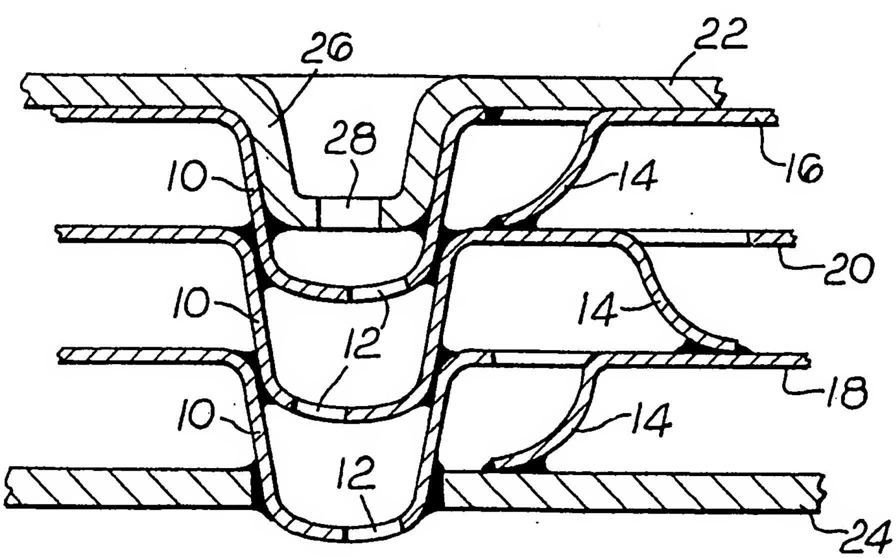


Fig. 3

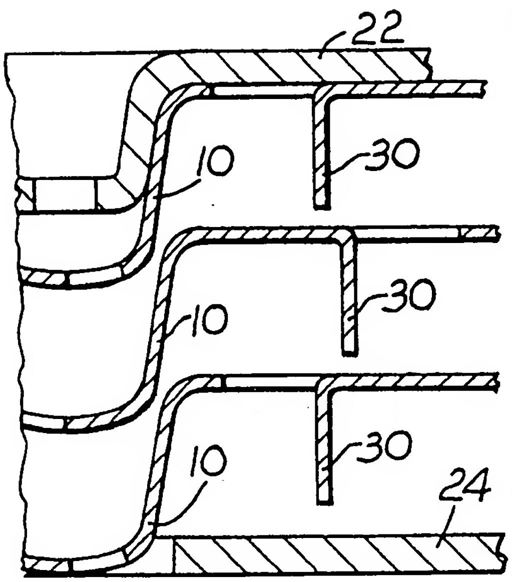


Fig. 4

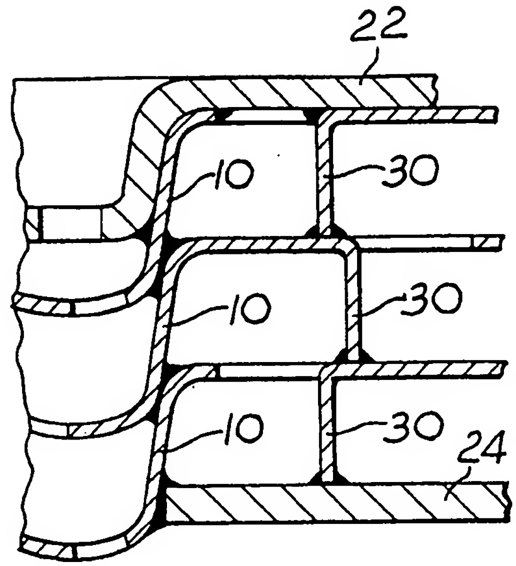


Fig. 5

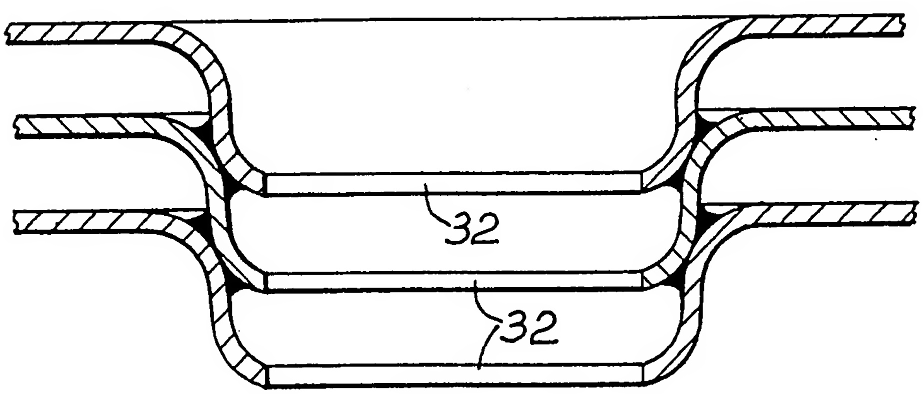
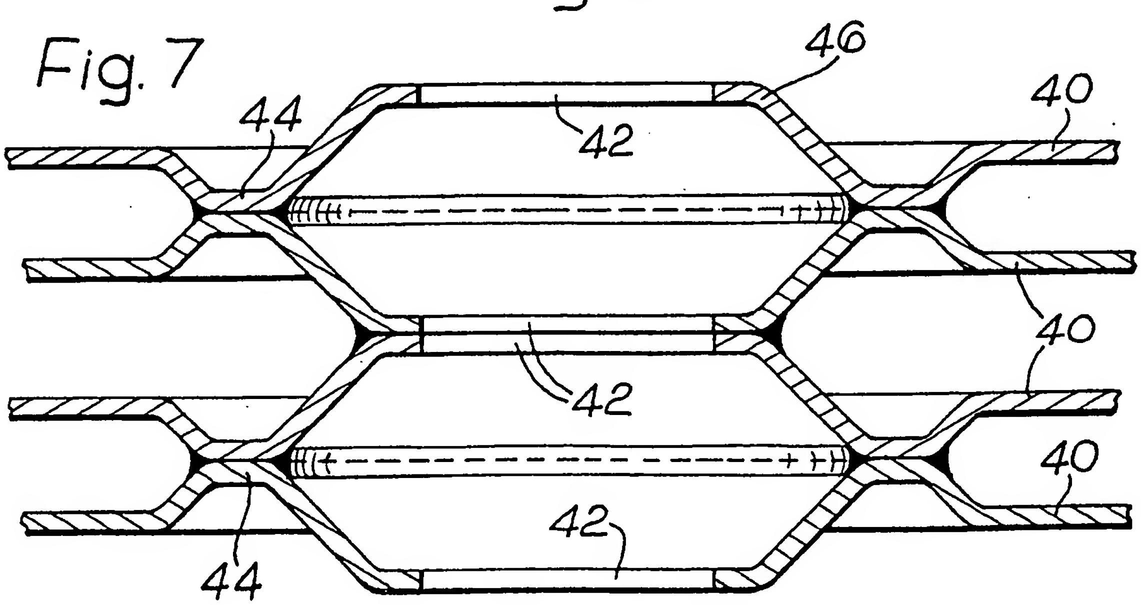


Fig. 6

Fig. 7



SPECIFICATION

Heat exchangers

It is known to make a heat exchanger from a stack of tubes with parallel axes and a series of parallel plates extending in planes normal to the axes, with the tubes extending through the plates, that is through aligned holes in the successive plates and bonded or otherwise connected around each hole for heat transfer, so that the plates act as fins. One fluid of the heat exchange pair for example water flows through the tubes and the other, for example air between the plates.

It is known for example from GB 2065281A to make an essentially tubeless heat exchanger of the kind mentioned in the preceding paragraph, by making a series of hollow projections in each fin plate and aligning these projections in stacked plates to form the tube. Figure 4 of said publication shows one tube in section, and Figure 3 of said publication shows the stack of fin plates with one of the tubes sectioned.

In practice there are difficulties in providing a satisfactory construction by the tubeless technique, for several reasons. One reason is that suitably thin metal for the fin plates can only be formed into the projections with difficulty because the projections inevitably involve metal flow and thinning. If the projections are axially short the fins have to be particularly close together (which itself may be undesirable) and in any event the number of joints along the length of the tube is high. Each joint needs to be made fluid-tight otherwise there will be leakage of one of the fluids.

A suitable technique for minimising leakage, in theory, is to use metal sheet or foil, and instead of solder dipping the assembly to make the joints, to use clad or coated sheet which effectively is provided with a thin film of the joining-metal over the whole of its surface. For example the metal may be aluminium which is theoretically a good material for a heat exchanger because of its conductivity, and is also advantageous because of its light weight and its price advantage as compared to copper for example. Aluminium is difficult to joint because of its well known tendency to oxidise. But clad aluminium, which is effectively a laminate of aluminium sheet with a brazing metal may be suitable

The object of the invention is to provide improved designs of heat exchanger for making tubeless structures, and for avoiding the mentioned problems.

According to the present invention a tubeless heat exchanger comprises a plurality of fin plates each formed with a series of hollow projections, the fin plates being assembled together so that the projections form tubular passages, and is characterised in that the fin plates are all identical and each plate in the stack of fin plates is reversed 180° relative to the next fin plate in the stack.

The invention embraces several distinct possibilities: in one possibility each fin plate has a projection in a first direction normal to the surface of the plate, and a second projection located within the first projection and extending to the opposite side of the same plate. The 180° reversal takes the first projections of two adjacent plates to extend towards one another, and the second projections of those two adjacent plates to extend away from one another. Hence in the stack, each plate contacts the next one in one direction by means of the first projection, and the next plate in the opposite direction through the stack by means of a second projection. In other words one plate is turned over relative to the next in the stack, and so on.

In another possibility, passages of sinuous shape are provided by making ports in each projection which are eccentric to the projection, and the 180° reversal is end-for-end of each plate so as to place the ports in a first plate towards one end of the fin plate and the ports in the next plate, with which that first plate is engaged towards the opposite end of the plate, and so on.

In another possibility, the plates are spaced apart by means of tag-like projections struck out of each fin plate, and the reversal of one plate relative to the next, whilst maintaining the projections extending in the same direction, ensures that each such tag contacts, at its free end, an unapertured portion of the next adjacent fin plate.

Two or more of these possibilities can be combined.

The invention is more particularly described with reference to the accompanying drawings wherein:-

Figure 1 is a plan view of a portion of a strip for use as a fin plate.

Figure 2 is a fragmentary sectional elevation showing three such fin plates assembled with header plates;

Figure 3 is a view similar to Figure 2 showing the same brazed together;

Figures 4 and *5* are views corresponding to Figures 2 and 3 but showing a modification;

Figure 6 shows a further modification; and

Figure 7 is a fragmentary sectional elevation of part of a different embodiment.

Referring first to the drawings, and particularly Figure 1 thereof, this shows a strip of for example aluminium foil clad with brazing metal which has been provided with a series of hollow projections 10, all extending in the same direction from the plane of the strip, and these being at a regular pitch interval, and being apertured eccentrically at 12. A series of tags 14 is struck out of the plane of the strip, and these are also at (the same) pitch interval along the length of the strip.The effect of the press operation or operations which form the projections is to deform the edges of the strip slightly as shown in the Figure, and it will be understood by those skilled in the art that the strip of Figure 1 has been manufactured from a strip which originally had parallel straight edges.

Figure 2 shows three of the strips as in Figure 1 assembled together, the first and third strips 16, 18 being arranged as illustrated in Figure 1 and the intermediate strip 20 being the strip of Figure 1 reversed through 180° so that the eccentric projections of the successive strips are not axially aligned.

It will be understood that in practice, in making a

heat exchanger, the strip may have more than one row of projections, although the flow of metal in making the projections may create difficulties unless the projections are particularly widely spaced, and for most purposes it will be preferred to use relatively narrow strips provided with only a single row of projections and after making several blocks each composed of a stack of strips, to assemble a complete heat exchanger with a plurality of such blocks. It sill also be understood by those skilled in the art that the length of the strip may comprise any required number of projections and usually far more than five illustrated in Figure 1 will be required, and usually far more than 3 strips to each block.

Figure 2 shows a top plate 22 and a bottom plate 24. The top plate has hollow projections 26 generally similar to the projections 10, and these may have central apertures 28: the bottom plate 24 simply has relatively large diameter holes at each interval to align with the fin plate projection, as shown.

The spacing of the generally parallel fin plates in Figure 2 is dictated by the tags 14.

When the stack is treated, for example in a furnace, under light axial pressure (relative to the length of the tubular passages formed by the successive projections 10) or possibly merely under the weight of the stack, the cladding brazing metal flows and with capillary action forms joints as generally indicated around all of the contacting sufaces. This provides what is, in this particular embodiment, a sinuous passage from each aligned and registered set of projections 10, the sinuosity being due to the eccentricity of the holes 12. The extent of axial collapse of the stack is limited by the tags. They also serve as bridging struts to strengthen the heat exchanger matrix blocks so formed.

It will be noted that because of the 180° of reversal of alternate ones of the fin plates, each tag 14 is aligned not with the edge of the aperture from which a tag has been struck in the next succeeding fin plate, but with a portion of the fin plate spaced from that aperture.

In a modification of Figures 4 and 5, the essential difference is that the tags extend at right angles to the plane of the fin plates. This provides more positive limitation to the axial contraction of the assembly in the brazing step and prevents over-travel with the successive projections being closed further together than was intended in the design. It will also be noted that each tag 35 has its free end located, and in practice brazed to, the next succeeding fin plate nearer to a co-linear position with itself so that the successive tags form a compression strut of inherently greater strength than is provided in the Figure 3 arrangement.

In a modification of Figure 6, the same tag arrangement as in either Figure 3 or Figure 5 is used, due to an alternation of direction of the strip in the same way as in the preceding arrangements, but here the apertures 32 in the projections are concentric to the projections so that the tubular passageway is not sinuous.

In the embodiment fragmentarily shown in Figure 7, the fin plates 40 are formed with regularly pitched apertures 42 which are concentrically located in annular pressings which provide an annular rib 44 which, in the case of the uppermost fin plate in Figure 7 extends downwardly from that plate, and within that rib or first projection is a second projection or dome 46 which extends through the plane of the fin plate and to the opposite side of the plate from the rib 44, the base of that dome being formed with the aperture 42. It will be seen that alternate plates are arranged in the same way, and the intermediate plates are reversed by being turned upside down, that is through 180°. Thus, counting from the top of the stack shown in Figure 7, the first and the third plates are in the same direction, and the second and fourth plates are in the reverse direction.

The arrangement shown in Figure 7 creates a tubular passageway including the aligned apertures 42, and the same material forms fins extending in planes normal to the axis of that passageway. Eccentric apertures could be used instead of concentric ones in this embodiment.

The nature of the projections shown in Figure 7 is a particularly advantageous one in terms of metal flow and enables fin plates to be provided with multiple rows of projections. This is possibly due to the fact that the effective projection and hence the spacing apart of the plates is doubled, so that for a given spacing of the fin plates the distortion effects from the pressing operation creating the projections may be half of what they would be for example in the Figure 1 arrangement. Moreover, by utilising a rib 44 with a flat base as illustrated, and also using a dome 66 with a flat base into which the apertures 42 are formed, this flat base is being effectively secured to successive fin plates in the stack, relatively large areas of each plate are in contact with the next plate so as to give a strong construction of closely controlled axial height without requiring the use of tags.

Instead of using clad aluminium, copper foil with an appropriate solder dip can be used, or other materials as appropriate.

The manufacturing methods described permit large tolerances because relatively large gaps are bridged by capillary action of the solder in the dipping process, or of the brazing metal in the furnace treatment of the clad aluminium for example, although a similar capillary action would be achieved in other bonding methods involving joining materials which are liquid during the bonding.

Heat exchangers made according to the present invention can easily be tuned, that is to say the relative flow rates of one fluid compared to the other can be varied, for example by varying the size of the apertures 12, or using relatively large apertures and inserting annular liners or threading a core wire o the like through the apertures so as to restrict flow through the tubular passageways. If it is desired to have the flow between the fin plates reduced, similar possibilities exist or masks can be applied across the edges of the stack.

It will be understood by those skilled in the art that a heat exchange stack will normally comprise a large number of fin plates and the three or four illustrated in the foregoing are for the purposes of exemplifica-

tion only.

CLAIMS

1. A tubeless heat exchanger comprising a plurality of fin plates each formed with a series of hollow projections assembled together so that the projections form tubular passages, characterised in that the fin plates are all identical and each plate in the stack of fin plates is reversed 180° relative to the next.

2. A heat exchanger as claimed in Claim 1 wherein each fin plate comprises a strip formed with at least one row of projections, and alternate plates are reversed end to end relative to the adjacent ones.

3. A heat exchanger as claimed in Claim 1 wherein each hollow projection includes an outer zone extending in one direction relative to the plane of the fin plate and an inner zone extending in the opposite direction, and alternate fin plates are reversed so that the first outer projection extends in one direction and in the next adjacent plate the corresponding outer projection extends in the opposite direction, and so on.

4. A heat exchanger as claimed in any preceding claim wherein each fin plate is provided with a plurality of tags struck out of the fin plate and arranged to contact the adjacent fin plate during assembly to form spaces therebetween.

5. A heat exchanger as claimed in Claim 4 wherein each tag is inclined to the plane of the fin plate.

6. A heat exchanger as claimed in Claim 4 wherein each tag extends normally of the plane of the fin plate.

7. A heat exchanger as claimed in any preceding claim wherein each projection is apertured eccentrically so that after the 180° reversal a sinuous passage is formed.

8. A heat exchanger as claimed in any of Claims 1 to 6 wherein each projection is apertured concentrically.

9. A heat exchanger as claimed in any one of Claims 4-8 wherein each fin plate comprises a narrow strip formed with a single row of projections at regular pitch entervals, and with one or more rows of tags at the same pitch.

10. A heat exchanger as claimed in Claim 3 wherein the outer zone is an annular rib projecting to one side of the plane of the fin and all of the outer zones of that fin plate extend in the same direction, and the inner zone in each case is a dome extending to the opposite side of the said plane.

11. A heat exchanger as claimed in Claim 10 wherein said annular rib has a flat base lying in a plane parallel to the plane of the fin and said domes have flat faces lying in a further parallel plane.

12. A heat exchanger as claimed in any preceding claim made of clad aluminium and made by heating the assembled stack of fin plates so as to provide capillary joints between them.

13. A heat exchanger substantially as described with reference to Figures 1 to 3 or Figures 4 and 5 or 6 or 7 of the accompanying drawings.

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